EUROPEAN PATENT SPECIFICATION

Date of publication and mention of the grant of the patent: 27.08.1997 Bulletin 1997/35

Application number: 93302726.0

Date of filing: 07.04.1993

IntCl. §: G01B 11/00

Non-contacting position detecting apparatus

Berührungsloses Positionsmessgerät

Detecteur de position sans contact

Designated Contracting States:
DE FR GB IT


Date of publication of application: 13.10.1993 Bulletin 1993/41

Proprietor: HONDA GIKEN KOGYO KABUSHIKI KAISHA
Minato-ku Tokyo (JP)

Representative: Tomlinson, Kerry John
Frank B. Dehn & Co.,
European Patent Attorneys,
179 Queen Victoria Street
London EC4V 4EL (GB)

Inventors:
• Takagi, Kiyoshi,
c/o K.K. Honda Gijutsu Kenkyusho
Wako-shi, Saitama (JP)
• Kurihara, Toshiio,
c/o K.K. Honda Gijutsu Kenkyusho
Wako-shi, Saitama (JP)
• Kuwahata, Shoichi,
c/o K.K.Honda Gijutsu Kenkyusho
Wako-shi, Saitama (JP)
• Ohomori, Kazuo,
c/o K.K. Honda Gijutsu Kenkyusho
Wako-shi, Saitama (JP)
• Toyama, Atsumi,
c/o K.K. Honda Gijutsu Kenkyusho
Wako-shi, Saitama (JP)
• Oba, Takeshi, c/o K.K. Honda Gijutsu Kenkyusho
Wako-shi, Saitama (JP)

Objection:

References cited:
EP-A- 0 322 676
DE-A- 2 008 948
DE-A- 2 609 670
DE-A- 2 613 451

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

The present invention relates to a non-contacting position detecting apparatus, and particularly to a non-contacting position detecting apparatus suitable for use with a non-contacting three-dimensional measuring instrument which can perform a reliable and accurate measurement of coordinates of various portions of an outer profile of a subject to be measured.

Three-dimensional measuring instruments which detect a three-dimensional shape as three-dimensional coordinate data are disclosed, for example, in U.S. Patents No. 3,722,842, No. 4,102,051, No. 4,149,317 and No. 4,282,654.

The three-dimensional measuring instruments include a body (arm) movable in the directions of axes of coordinates of a spatial rectangular coordinate system, that is, X, Y and Z axes which are perpendicular to each other, and a needle provided on the movable body. The needle contacts with a detection point of an outer profile of a subject for measurement to detect three-dimensional coordinates of the movable body upon such contacting to measure a three-dimensional profile.

However, with such contacting three-dimensional measuring instruments, where the subject for measurement is molded from a soft material such as, for example, clay, when an end of the needle is contacted with the detection point of the subject for measurement, the end is liable to bite into the subject for measurement so that an error is produced in detected coordinates of the subject for measurement. There is the possibility that concave and convex measurements may be produced on the outer profile of the subject for measurement.

In order to eliminate such a disadvantage, the three-dimensional measuring instrument should be of the non-contacting type wherein, for example, a laser light source and a light receiving element for receiving a reflected laser beam are used, the distance between the subject for measurement and the laser light source is measured and, at a point in time when the distance reaches a predetermined value, coordinates of the detection point of the subject for measurement are measured (see e.g. EP-A-0 322 676).

With a contacting three-dimensional measuring instrument, when the needle is directed perpendicularly to a predetermined position of the surface of a subject for measurement, coordinates of the position can be detected accurately. Accordingly, in such a non-contacting three-dimensional measuring instrument as described above, detection of coordinates is performed using such a customary technique.

The technique of detection of coordinates described above is described with reference to Figures 7(a) and 7(b). Referring to Figures 7(a) and 7(b), the Y-axis is disposed in a direction perpendicular to the plane of the figure. A subject for measurement 100 is provided adjacent to a laser unit 10 having a laser light source and a light receiving element for a laser beam disposed therein for detecting the distance to the subject 100 for measurement in a non-contacting condition.

The structure of the laser unit 10 is shown in Figure 12. Laser light radiated from a semiconductor laser 12, which is a light emitting element, is radiated upon the subject 100 for measurement. When the subject 100 for measurement is disposed at a reference point Lref (for example, at the distance of 50 mm in the laser light irradiation direction from the laser light irradiation position of the laser unit 10), laser light reflected at random from a detection point of the subject 100 for measurement is received at a central position of a light receiving element 15. Further, when the position of the subject 100 for measurement is nearer (100A) or farther (100B) than the reference point, Lref, the light receiving position of laser light on the light position detecting element 15 moves in the direction of an arrow mark A or B. The output of the light position detecting element 15 is outputted to a first signal processing circuit 50, as illustrated in Figure 6.

When measurement is performed using such a laser unit 10, as shown in Figure 7(a), the mounting position of the laser unit 10 is set so that laser light 10A radiated from the laser unit 10 is radiated substantially perpendicularly upon a portion (detection point) of the subject 100 for measurement whose coordinates are to be detected, and thereafter, the laser unit 10 is fed in the X and Z directions simultaneously so that the laser unit 10 may move in the irradiation direction (the direction of an arrow mark L) of the laser light. When the laser unit 10 is moved closer to the subject 100 for measurement as shown in Figure 7(b), laser light 10B reflected from the subject 100 for measurement is detected by way of a lens system. When the laser unit is moved from the result of the detection that the laser unit 10 comes to a predetermined distance from the laser unit 10, coordinate data of the laser unit 10 or of an arm (not shown) which supports the laser unit 10 thereon are then collected as coordinate data corresponding to the laser light radiation position (detection point) of the subject 100 for measurement.

As illustrated in Figures 15(a) to 15(c), a light emitting portion 101A and a light receiving portion 101B are provided for the laser light. As shown in Figure 15(a), the mounting position of the laser unit 101 is set so that laser light irradiated from the light emitting portion 101A of the laser unit 101 is radiated substantially perpendicularly upon a portion of the subject 100 wherein the coordinates are to be measured. Thereafter, the laser unit 101 is fed in the X and Z directions simultaneously so that the laser unit 101 may move in the irradiation direction (the direction of an arrow mark L) of the laser light. When the laser unit 101 is moved closer to the subject 100 for measurement as shown in Figure 15(b), laser light reflected from the subject 100 for measurement is detected by way of a lens system provided at the light receiving portion 101B. When the resulting signal is fed into the first signal processing circuit 50, the laser unit 101 is then moved in the X and Z directions simultaneously so that the laser light may be detected in the predetermined distance from the laser unit 101.
101 has arrived at a predetermined distance from the laser unit 101, coordinate data of the laser unit 101 or of an arm (not shown) which supports the laser unit 101 thereon is collected as coordinate data corresponding to the laser light irradiation position of the subject 100 for measurement.

With the non-contacting three-dimensional measuring instrument of the construction described above, since it does not include means for indicating such a desired detection point as corresponds to a needle of a contacting three-dimensional measuring instrument, it is difficult to designate a desired detection point rapidly and accurately. Accordingly, when it is tried to continuously measure a plurality of detection points on a curved line of a subject for measurement which has, for example, a curved profile, there is a problem that the operability is very inferior compared with that of a contacting three-dimensional measuring instrument.

It is an object of the present invention to make it possible to designate a desired detection point rapidly and accurately with a non-contacting position detecting apparatus solving the problems of the prior art described above.

In order to attain the object of the present invention, a non-contacting position detecting apparatus which includes a laser unit having a light emitting portion and a light receiving portion for irradiating laser light upon a detection point of a subject for measurement and receiving laser light reflected from the detection point to recognize the distance to the detection point is characterized in that the laser unit includes needle-like indicating means for indicating the crossing point between extension lines of an optic axis of the laser light radiated from the light emitting portion and an optic axis of laser light received by the light receiving portion when the detection point and the laser unit reach the predetermined positional relationship.

Since the needle-like indicating means described above is provided on the laser unit, if the laser unit is moved so that the needle-like indicating means may indicate a detection point, then the positional relationship between the detection point and the laser unit comes to the predetermined relationship, and accordingly, the desired detection point can be designated rapidly and accurately.

In a system wherein the irradiation direction L of laser light is directed perpendicularly to a predetermined surface of an outer profile of a subject for measurement and a laser unit is moved in the irradiation direction as described above, the laser unit 101 must necessarily be moved in the directions of two axes (the X-axis and the Z-axis in the example of Figures 15(a) to 15(c)) or in the directions of three axes simultaneously. In short, in order to move the laser unit 101 from the condition of Figure 15(a) to the condition of Figure 15(b), the laser unit 101 must necessarily be fed by xf in the X direction and by zf in the Z direction simultaneously as shown in Figure 15(c). Such simultaneous feeding of the laser unit 101 in the directions of a plurality of axes not only makes the mechanism much more complicated but also reduces the operability.

Meanwhile, in a method wherein the simultaneous feeding described above is performed separately (for example, feeding by xf in the X direction is performed first, and then, feeding by zf in the Z direction is performed) or another method wherein feeding in the X direction and feeding in the Z direction are performed alternately little by little, there is the possibility that, at the point in time when the laser unit 101 comes to a predetermined distance to the subject 100 for measurement (that is, at a point in time when coordinates are detected) the irradiation position of laser light may be a different position from an aimed position to be detected. In this instance, coordinates of the aimed position cannot be detected. It is a further object of the present invention to provide a non-contacting three-dimensional measuring instrument which can readily effect detection of coordinates of a desired (aimed) position of a subject for measurement.

Thus, in a preferred embodiment, the non-contacting three-dimensional measuring instrument is constructed using a main shaft provided on the arm of a layout machine such that the direction of the center axis thereof extends in the direction of one of axes of the coordinates of a spatial rectangular coordinate system, a first intermediate arm provided for pivotal motion on the main shaft, an auxiliary shaft provided on the first intermediate arm at an angle of 45 degrees with respect to the main shaft, and a second intermediate arm provided for pivotal motion on the auxiliary shaft, the laser unit being mounted on the second intermediate arm such that the direction of laser light irradiated from the laser unit makes an angle of 45 degrees with respect to the auxiliary shaft.

The non-contacting three-dimensional measuring instrument may be constructed such that a point (hereinafter referred to as "reference point") at a predetermined distance in the laser light irradiation direction from the laser unit, which is positioned for making a reference for collecting coordinates, may be positioned at the crossing point between the main shaft and the auxiliary shaft.

The non-contacting three-dimensional measuring instrument may include a laser unit constructed so as to provide irradiated laser light from a position other than a central portion thereof, and the laser unit may be able to be reversely mounted with regard to its front and rear sides.

The non-contacting three-dimensional measuring instrument may include a first intermediate arm having a core member made of an epoxy honeycomb, a pair of bearings disposed at the opposite ends of the core member and carbon fibers wound on the surfaces of the core member and the bearings.

With the non-contacting three-dimensional measuring instrument according to a preferred embodiment, the
laser light irradiation direction can be directed to all of the directions of the three axes constituting the coordinate system by adjusting the pivoting angle of the first intermediate arm with respect to the main shaft and the pivoting angle of the second intermediate arm with respect to the auxiliary shaft.

With the non-contacting three-dimensional measuring instrument according to a preferred embodiment, if the laser unit is mounted reversely with the front side positioned on the rear side, measurement of coordinates can be performed in the proximity of a wall face of a recessed portion of the surface of the subject for measurement.

With the non-contacting three-dimensional measuring instrument according to a preferred embodiment, the first intermediate arm can be constructed light and firmly.

Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the scope of the invention will become apparent to those skilled in the art from this detailed description.

The present invention will become more fully understood from the detailed description given hereinafter and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:

Figure 1 is a schematic view of a laser unit 10 according to an embodiment of the present invention; Figure 2(a) is an enlarged view of the principal portion illustrated in Figure 1, and Figure 2(b) is a sectional view taken along line 2-2 of Figure 2; Figure 3 is a perspective view of a laser unit constructed according to a second embodiment of the present invention; Figure 4 is an enlarged view of an end portion of a needle 302; Figure 5 is a partial enlarged view of Figure 6; Figure 6 is a schematic view of a non-contacting measuring instrument according to an embodiment of the invention; Figure 7(a) and 7(b) are views illustrating conventional techniques for detecting coordinates; Figure 8 is a front elevational view of a wing arm 20; Figure 9 is a sectional view taken along line 9-9 of Figure 8; Figure 10(a), 10(b) and 10(c) are schematic views illustrating the relationship between pivoting positions of an intermediate arm 30 and a wing arm 20 and the laser light irradiation direction L; Figures 11(a), 11(b) and 11(c) are views illustrating a method of detecting coordinates of a recessed portion according to the present invention; Figure 12 is a view showing a conventional non-contacting coordinate detecting method; Figure 13 is a partial enlarged view of Figure 6; Figures 14(a), 14(b) and 14(c) are views illustrating a technique for adjusting the distance between the laser unit and a subject for measurement according to an embodiment of the present invention; Figures 15(a) and 15(b) are views for illustrating a conventional technique of detection of coordinates and illustrating the positional relationships between a laser unit and a subject for measurement; Figure 15(c) is a graph showing variation of coordinates when a laser unit is moved from the condition of Figure 15(a) to the condition of Figure 15(b); Figure 16(a) is a front elevational view of a pair of epoxy honeycombs constituting the intermediate arm and Figure 16(b) is a sectional view thereof taken along line 16-16 of Figure 16(a); Figure 17(a) is a view illustrating a manner in which carbon fibers are adhered to the pair of epoxy honeycombs and Figure 17(b) is a sectional view taken along line 17-17 of Figure 17(a); Figure 18 is a view, similar to Figure 17(b), illustrating the carbon fibers being adhered to the pair of epoxy honeycombs; Figure 19 is a front elevational view of a jig apparatus according to the present invention; Figure 20 is a view illustrating the positioning of the bearing mounted on the jig apparatus; Figure 21 illustrates a bearing for mounting at an end of the pair of epoxy honeycombs to which the carbon fibers are adhered thereto; and Figure 22 illustrates a bearing and a pair of epoxy honeycombs to which the carbon fibers are adhered, wherein the bearing is mounted on the jig apparatus.

Figure 1 illustrates the construction of a principal portion of a laser unit 10 to which the present invention is applied. A needle-like indicating means 300 is provided for indicating a desired detection point on a subject 100 for measurement. Figure 2(a) is an enlarged view showing the construction of the needle-like indicating means 300 in detail, and Figure 2(b) is a sectional view taken along line 2-2 of Figure 2(a). The needle-like indicating means 300 includes a base plate 303 securely mounted, for example, on the laser unit 10, a supporting portion 301 having a tapping hole 301a, and a needle 302 screwed at a rear end thereof in the tapping hole 301a of the supporting portion 301 and having an end portion of a ta-
The base plate 303 and the supporting portion 301 are secured to each other by a weak restraining force so that, when the needle 302 collides with the subject 100 for measurement, they may be spaced away from each other readily to prevent damage to the subject 100. The securing by such a weak restraining force can be achieved, for example, by a magnetic force such as a magnet MG. As illustrated in Figures 2 and 4, the end tip 302a of the needle 302 is pointed.

The needle 302 is transparent, and, as shown in Fig. 4, an end portion is roughened so that laser light is randomly reflected from it.

Figure 6 illustrates a noncontacting three-dimensional measuring instrument provided with the laser unit 10 described above, and like reference characters to those described above denote like or equivalent portions. In the following, the present invention will be described by applying the invention to the non-contacting three-dimensional measuring instrument, but the present invention is not limited to this and can be applied similarly to a one-dimensional measuring instrument for measuring the length of a subject 100 for measurement in a one-dimensional direction in a non-contacting condition or a two-dimensional measuring instrument for measuring the lengths in two-dimensional directions in a noncontacting condition.

Referring to Figure 6, a layout machine 1 is installed on a surface plate 200, and a guide rail 2 thereof is secured to the surface plate 200. A base plate 3 of the layout machine 1 is slidably movable in the Y direction along the guide rail 2, and a sliding frame 5 is slidably movable in the Z direction along a vertical arm 4 supported vertically on the base plate 3. Further, a horizontal arm 6 is slidably movable in the X direction along the sliding frame 5.

A laser unit 10 is mounted at an end of the horizontal arm 6 by way of an intermediate arm (first intermediate arm) 30 and a wing arm (second intermediate arm) 20. The mounting of the wing arm 20 and the laser unit 10 may be, for example, by screwing.

Accordingly, the laser unit 10 is moveable to a suitable location within a three-dimensional space above the surface plate 200 by sliding movements of the base plate 3, the sliding frame 5 and the horizontal arm 6 in the respective directions described above. The movement of the laser unit 10, that is, the sliding movements of the base plate 3, the sliding frame 5 and the horizontal arm 6 in the respective directions described above, can be performed by a suitable known technique by means of a motor or by a manual operation or the like.

A cable 99 connected to the laser unit 10 is connected to a first signal processing circuit 50 described above. The first signal processing circuit 50 outputs, depending upon a difference of the light receiving position of laser light on the light position detecting element 15, an analog signal corresponding to the distance between the laser unit 10 and the subject 100 for measurement. For example, when the distance between the laser unit 10 and the subject becomes smaller or larger than a preset distance, a digital signal may be outputted representing the distance. For the laser unit 10 and the first signal processing circuit 50, for example, a laser displacement gauge (LC-2320) and a controller (LC-2100) manufactured by Keyence Kabushiki Kaisha can be used.

The first signal processing circuit 50 is connected to a personal computer 70. A second signal processing circuit 60 includes a time constant circuit for applying the invention to the non-contacting three-dimensional measuring instrument provided with the laser unit 10 described above, and like reference characters to those described above denote like or equivalent portions. In the following, the present invention will be described by applying the invention to the non-contacting three-dimensional measuring instrument, but the present invention is not limited to this and can be applied similarly to a one-dimensional measuring instrument for measuring the length of a subject 100 for measurement in a one-dimensional direction in a non-contacting condition or a two-dimensional measuring instrument for measuring the lengths in two-dimensional directions in a noncontacting condition.

Referring to Figure 6, a layout machine 1 is installed on a surface plate 200, and a guide rail 2 thereof is secured to the surface plate 200. A base plate 3 of the layout machine 1 is slidably movable in the Y direction along the guide rail 2, and a sliding frame 5 is slidably movable in the Z direction along a vertical arm 4 supported vertically on the base plate 3. Further, a horizontal arm 6 is slidably movable in the X direction along the sliding frame 5.

A laser unit 10 is mounted at an end of the horizontal arm 6 by way of an intermediate arm (first intermediate arm) 30 and a wing arm (second intermediate arm) 20. The mounting of the wing arm 20 and the laser unit 10 may be, for example, by screwing.

Accordingly, the laser unit 10 is moveable to a suitable location within a three-dimensional space above the surface plate 200 by sliding movements of the base plate 3, the sliding frame 5 and the horizontal arm 6 in the respective directions described above. The movement of the laser unit 10, that is, the sliding movements of the base plate 3, the sliding frame 5 and the horizontal arm 6 in the respective directions described above, can be performed by a suitable known technique by means of a motor or by a manual operation or the like.

A cable 99 connected to the laser unit 10 is connected to a first signal processing circuit 50 described above. The first signal processing circuit 50 outputs, depending upon a difference of the light receiving position of laser light on the light position detecting element 15, an analog signal corresponding to the distance between the laser unit 10 and the subject 100 for measurement. For example, when the distance between the laser unit 10 and the subject becomes smaller or larger than a preset distance, a digital signal may be outputted representing the distance. For the laser unit 10 and the first signal processing circuit 50, for example, a laser displacement gauge (LC-2320) and a controller (LC-2100) manufactured by Keyence Kabushiki Kaisha can be used.

The first signal processing circuit 50 is connected to a personal computer 70. A second signal processing circuit 60 includes a time constant circuit for applying output delaying processing for prevention of chattering to an output signal (for example, a signal of a distance between the laser unit 10 and the subject for measurement) of the first signal processing circuit 50, an inverter circuit and so forth. It is to be noted that the second signal processing circuit 60 can be omitted in accordance with a responding condition, a polarity or the like of the output signal of the first signal processing circuit 50.

The layout machine 1 includes a coordinate detecting apparatus 1A for detecting coordinates of the horizontal arm 6 (in other words, coordinates of the reference point Lref), and the output signal thereof is outputted to the personal computer 70. The personal computer 70 automatically collects coordinates of the reference point Lref which are an output signal of the coordinate detecting apparatus 1A at a point in time when the subject 100 for measurement reaches the reference point Lref, using the output signal of the second signal processing circuit 60 (or the first signal processing circuit 50), and reproduces, in accordance with the requirements, the shape of a profile of the subject for measurement on a CRT using the collected coordinate information. The automatic collection of coordinates will be hereinafter described.

Figure 13 is a front elevational view of the horizontal arm 6 and the intermediate arm 30, wing arm 20 and laser unit 10 mounted on the horizontal arm 6. A pair of bearings 32 and 34 are securely mounted at the opposite ends of the intermediate arm 30, and a main shaft 31 and an auxiliary shaft 33 are inserted for rotation in the bearings 32 and 34. The main shaft 31 is secured to a shaft 6A mounted for rotation at an end of the horizontal arm 6 while the auxiliary shaft 33 is secured to the wing arm 20.

Accordingly, an end portion is farther than the main shaft 31 and the intermediate shaft 30 can be pivoted in the direction indicated by an arrow mark P around the shaft 6A. An end portion farther than the intermediate arm 30 can be pivoted in the direction indicated by an arrow mark Q around the main shaft 31. In addition, an end portion farther than the wing arm 20 can be pivoted in the direction indicated by an arrow mark R around the auxiliary shaft 33. The pivotal portions are fixed using a suitable known technique upon measurement of coordinates by the present non-contacting three-dimensional measuring instrument.

Now, as shown in Figure 5, the main shaft 31 and
the auxiliary shaft 33 provided on the intermediate arm 30 are mounted such that the angle defined by extension lines of the center axes thereof may be 45 degrees. The needle 302 is installed within the region defined between extension lines of an optic axis Lo of laser light radiated from the light emitting portion and an optic axis Li of laser light received by the light receiving portion when the detection point is at the reference point Lref.

Since originally the region is a region which is assured as a dead spacing into which no cables or the like are admitted in order that laser light may be irradiated with certainty upon a subject for measurement and laser light reflected from the subject for measurement may be received with certainty, if the needle 302 is provided in the region, the needle 302 will not be connected to cables or the like.

Meanwhile, the laser unit 10 is mounted on the wing arm 20 such that laser light L irradiated in the direction of an arrow mark from the laser unit 10 may make an angle of 45 degrees with respect to the center axis of the auxiliary shaft 33.

Accordingly, if the horizontal arm 6 is directed in the X direction as shown in Figure 6, then if the center line of the main shaft 31 is directed in the X-axis direction so as to be parallel (imaginary line in Figure 13) to the center line of the horizontal arm 6, the irradiation direction L of laser light radiated from the laser unit 10 can be made to coincide with any one of the X, Y and Z directions as shown in Figures 10(a) to (c) by changing the pivoting position of the intermediate arm 30 with respect to the main shaft 31 and the pivoting position of the wing arm 20 with respect to the auxiliary shaft 33.

In the embodiment of the present invention, when laser light is irradiated in the X direction as shown in Figures 14 (a) and 14(b), the distance to the subject 11 for measurement can be adjusted by feeding the laser unit 10 only in the same direction without varying the irradiation position of the laser light. Accordingly, detection of coordinates of an outer profile of the subject 11 for measurement by the non-contacting three-dimensional measuring instrument can be performed readily. While, naturally with such a coordinate detecting method, laser light cannot be irradiated perpendicularly upon a position of the subject 11 for measurement for which coordinates are to be detected, since the coordinate detecting method is of the non-contacting type employing laser light, no deterioration of the accuracy in detection of the coordinate position occurs.

Further, according to the present embodiment, it is also possible to direct the irradiation direction of laser light to a direction other than the directions of the three axes described above by pivoting the intermediate arm 30 in the direction of the arrow mark P (Figure 13) with respect to the shaft 6A.

The laser unit 10 is constructed such that it does not irradiate laser light from a central portion thereof but irradiates laser light from a position near a side face thereof. When a recessed portion 100C is formed on the surface of the subject 100 for measurement as shown in Figure 11(a), it is possible to approach a delay angle of the wall face of the recessed portion 100C to effect detection of the coordinates. Further, since the mounting means of the laser unit 10 on the wing arm 20 may be by screws as described hereinabove, if the laser unit 10 is mounted on the wing arm 20 with the front side directed backwardly, then even if a recessed portion 100D is formed in the direction opposite to that of Figure 11(a) as shown in Figure 11(b), it is possible to approach the wall face of the recessed portion 100D to effect detection of coordinates at many positions.

It is to be noted that, when the laser unit 10 is mounted reversely, the reference point Lref is not on the crossing point between the main shaft 31 and the auxiliary shaft 33 as shown in Figure 11(b), but if the arm 20 is formed such that it is extended in the direction of the center axis of the main shaft 31 (refer to Figure 11(c)) when the wing arm 20 is in the condition of Figure 11(a), then it is possible to mount the laser unit 10 such that the reference point Lref may be positioned on the crossing point between the main shaft 31 and the auxiliary shaft 33 even if the laser unit 10 is directed with the front side directed backwardly.

In this manner, in the present embodiment, measurement of the inside of a recessed portion can be performed readily and with a high degree of accuracy. In other words, interference is small and the measurement limit is high.

Further, in the present embodiment, since the laser unit 10 is mounted on the wing arm 20 such that the reference point L1 is positioned at the crossing point between the center axes of the main shaft 31 and the auxiliary shaft 33, even if, for example, the wing arm 20 and/or the intermediate arm 30 are pivoted to vary the irradiation direction of laser light as shown in the several views of Figures 10(a) to 10(c), the position of the reference point Lref does not vary.

Accordingly, even if any of the arms 20 and 30 is pivoted, there is no need of adjusting the origin of the layout machine 1 every time.

Referring back to Figure 13, a cable 99 for a power source supply and data outputting led out from the laser unit 10 extends through the inside of the auxiliary shaft 33 and the inside of the horizontal arm 6, which have a hollow structure. The cable extends out from the rear end of the horizontal arm 6. Since the cable 99 is accommodated in the horizontal arm 6 in this manner, the cable 99 does not interfere with a measuring operation and protection of the cable 99 can be achieved. Further, also the quantity of guides (for example, tapes) for fixation of the cable necessary for bundling outer cables is decreased and the appearance is not deteriorated. It is to be noted that also the intermediate arm 30, the main shaft 31 and so forth may have a hollow structure so that the cable 99 may extend also through the insides of the hollow structures.

The intermediate arm 30, wing arm 20 and laser unit
10 mounted at the end portion of the horizontal arm 6 (Figure 6) must be constructed to be of light weight in order to raise the accuracy in three-dimensional measurement. To this end, the wing arm 20 on which the laser unit 10 is mounted has such a framed construction as shown in Figure 8. A shaft hole 21 in which the auxiliary shaft 33 is to be inserted and mounting holes 22 for mounting the laser unit 10 therein are perforated at suitable positions of the wing arm 20. Further, recessed portions 23 are perforated at the front and back portions of several linear members forming the framed construction described above in order to achieve reduction of the weight of the wing arm 20 (refer to Figure 9).

Due to such construction, reduction in the weight and high rigidity of the wing arm 20 can be achieved. Further, in order to achieve further reduction of the weight and enhance the accuracy of dimensions, the wing arm 20 is produced, for example, from magnesium.

It is to be noted that, while the needle 302 in the embodiment described above is described as being installed within the region (parallel to the optic axes LO and LI) defined between the optic axis LO of laser light radiated from the light emitting portion and the optic axis LI of laser light received by the light receiving portion when the detection point is at the reference point Lref with respect to the laser unit 10, the present invention is not limited to this construction. The needle 302 may be installed in such a manner, for example, as shown in Figure 3 only if it can indicate the crossing point between the optic axes LO and LI.

As is apparent from the foregoing description, according to the present invention, the following effects are achieved:

(1) Since the needle 302 is provided on the laser unit 10 and the positional relationship between the detection point and the laser unit may come to the predetermined relationship when the laser unit 10 is moved so that the end of the needle 302 may indicate the detection point, the desired detection point can be designated rapidly and accurately.

(2) If the needle 302 is secured in a readily removable condition to the laser unit 10, then the needle 302 is removed when it is contacted with a subject for measurement and will not damage the subject for measurement.

(3) If the needle 302 is screwed at a rear end portion thereof in the tapping hole of the supporting portion 301, then positioning of the end portion thereof is very easy.

(4) If the supporting portion 301 in which the needle 302 is screwed and the base plate 303 secured to the laser unit 10 are secured to each other by a magnetic force, then the securing of the needle 302 in a readily removable condition can be achieved with a simple construction.

(5) If the needle 302 is disposed so that laser light may be irradiated at the end portion thereof, then designation of the detection point can be readily performed.

(6) If the needle 302 is a transparent member, then admission of randomly reflected light into the light receiving portion is prevented.

(7) If the end portion of the needle 302 is roughened, then since laser light is reflected at random at the end portion, it can be readily visually observed.

(8) If the needle 302 is installed within the range defined by extension lines of the optic axis of laser light radiated from the light emitting portion and the optic axis of laser light received by the light receiving portion when the detection point and the laser unit 10 are in the predetermined positional relationship, the needle 302 is not contacted with cables or the like.

In a preferred embodiment, the intermediate arm 30 on which a wing arm 20 is mounted is produced by winding carbon fibers on an outer periphery of an epoxy honeycomb, which is to make a core member, and securely mounting bearings 32 and 34 onto the opposite ends of the epoxy honeycomb using a jig. In the following, the structure and the manufacturing process of the intermediate arm 30 will be described with reference to Figures 16(a) to 22. It is to be noted that hatching lines are omitted in Figures 16(b), 17(b) and 18.

First, as shown in Figures 16(a) and 16(b), a pair of epoxy honeycombs 3035, 3036 which are to make a core member of the intermediate arm 3030 and construct part of an annular shape are adhered in an opposing relationship to each other. Then, carbon fibers 3037 are adhered to the surface of the epoxy honeycomb 3035 as shown in Figures 17(a) and 17(b), and carbon fibers 3037 are adhered also to the surface of the epoxy honeycomb 3036. The adhesion is performed, for example, by disposing the carbon fibers 3037 in advance in a female die having a profile shape similar to that of the epoxy honeycomb 3035 or 3036 and inserting the epoxy honeycomb 3035 or 3036 into the female die. It is to be noted that the adhesion of the carbon fibers 3037 may be performed before the epoxy honeycombs 3035 and 3036 are adhered to each other. Thereafter, carbon fibers 3038 are wound once more on and adhered to the carbon fibers 3037.

It is to be noted that, since the carbon fibers are longer than the epoxy honeycombs 3035 and 3036, recessed portions 3039 for mounting the bearings 3032 and 3034, which will be hereinafter described, are formed at the opposite ends of the epoxy honeycombs 3035 and 3036 as a result of adhesion of the carbon fibers.

After the adhesion of the carbon fibers is completed in this manner, the bearings (slide bearing) 3032 and 3034 made of, for example, aluminium are mounted using such a jig apparatus 3110 as shown in Figure 19. Referring to Figure 19, first, a column portion 3112B is formed on a first mounting jig 3112 such that a mounting face 3112A perpendicular to the center axis of the first
mounting jig 3112 may be formed, and a male screw 3112C is formed at an end of the column portion 3112B. Further, another male screw 3112D is formed on the opposite side to the male screw 3112C, and the first mounting jig 3112 is mounted on a jig plate 3111 by screwing a nut 3115 on the male screw 3112D.

A second mounting jig 3113 is mounted on the jig plate 3111 such that a mounting face 3113A thereof makes an angle of 45 degrees with respect to the mounting face 3112A. Further, a hole portion 3113B is perforated perpendicularly to the mounting face 3113A in the mounting face 3113A.

A third mounting jig 3114 is constituted from a column portion 3114A, a leg portion 3114B having a smaller diameter than the column portion 3114A and a male screw 3114C formed at an end of the leg portion 3114B. In Figure 19, the third mounting jig 3114 is mounted on the second mounting jig 3113 by inserting the leg portion 3114B into the hole portion 3113B and screwing the male screw 3114C in the nut 3116, but before positioning of the intermediate arm 3030, the third mounting jig 3114 is in a removed condition.

In order to produce the intermediate arm 3030 using such a jig apparatus 3110, first, the bearing 3032 is fitted onto the column portion 3112B of the jig apparatus 3110 as shown in Figure 20, and after the insertion, the nut 3118 is screwed onto the male screw 3112C with a washer 3117 interposed therebetween to secure the bearing 3032 in a condition wherein the bearing 3032 is closely contacted with the mounting face 3112A.

Subsequently, a protruded portion 3034A of the bearing 3034 is inserted as shown in Figure 21 into one of the recessed portions 3039 of the epoxy honeycombs 3035 and 3036 around which carbon fibers are wound as described hereinabove with reference to Figs. 16(a), 16(b), 17(a), 17(b) and 18. In this condition, the bearing 3034 is secured to the mounting face 3113A so that a protruded portion 3032A of the bearing 3032 secured to the first mounting jig 3112 may be inserted into the other recessed portion 3039 as shown in Figure 26. The securing is performed by inserting the column portion 3114A of the third mounting jig 3114 into the bearing 3034 as shown in Figure 22. Thereafter, the leg portion 3114B is inserted into the hole portion 3113B and then the nut 3116 is screwed onto the male screw 3114C. Consequently, the bearing 3034 is closely contacted with the mounting face 3113A.

The shaft holes formed in the bearings 3032 and 3034 are formed perpendicularly to end faces which abut with the mounting faces 3112A and 3113A. Accordingly, as the bearings 3032 and 3034 are closely contacted with the mounting faces 3112A and 3113A which are disposed at an angle of 45 degrees relative to each other. Also the shaft holes formed in the bearings 3032 and 3034 finally make an angle of 45 degrees relative to each other. It is to be noted that, when the protruded portions 3032A and 3034A of the bearings 3032 and 3034 are inserted into the recessed portion 3039, a bonding agent is interposed between them.

After the condition shown in Figure 22 is set, the carbon fibers are wound on outer peripheries of the bearings 3032 and 3034 using a bonding agent so that they may be fixed relative to each other. By the winding, the bearings 3032 and 3034 are fixed to the epoxy honeycombs 3035 and 3036 as well as the carbon fibers 3037 and 3038, and consequently, the intermediate arm 3030 is completed. After the intermediate arm 3030 is completed, the nuts 3116 and 3118 are removed and the intermediate arm 30 is removed from the jig apparatus 3110.

The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. A non-contacting position detecting apparatus comprising:

   a unit (10) having a light emitting portion (12) and a light receiving portion (15) for irradiating laser light upon a detection point of a subject for measurement and receiving laser light reflected from the detection point to recognize the distance to the detection point;

   an arm (6) capable of moving said laser unit (10) in the direction of at least one axis of a rectangular coordinate system; and

   coordinate detecting means (1A) for detecting coordinates of said arm (6), and wherein coordinates of the detection point are recognized in accordance with the coordinates of said arm (6) when the positional relationship between the detection point and said laser unit (10) reaches a predeterminated relationship.

characterised in that

said laser unit (10) includes needle-like indicating means (300) for indicating the crossing point between extension lines of an optic axis (L) of laser light radiated from said light emitting portion (12) and an optic axis (L) of laser light received by said light receiving portion (15) when the detection point and said laser unit (10) reach the predeterminated positional relationship.

2. A non-contacting position detecting apparatus according to claim 1, wherein said needle-like indicating means (300) is readily, removably secured to said laser unit (10).

3. A non-contacting position detecting apparatus ac-
A non-contacting position detecting apparatus according to claim 1 or 2, wherein said needle-like indicating means includes a base plate (303) secured to said laser unit (10), a supporting portion (30) having a tapping hole (301a) and secured to said base plate (303) with a comparatively weak holding force, and a needle (302) screwed in said tapping hole (301a) of said supporting portion (301).

4. A non-contacting position detecting apparatus according to claim 3, wherein said needle-like indicating means (300) has a roughened surface.

5. A non-contacting position detecting apparatus according to any preceding claim, wherein said needle-like indicating means (300) is disposed so that laser light may be irradiated at an end portion thereof.

6. A non-contacting position detecting apparatus according to any preceding claim, wherein said needle-like indicating means (300) is constructed from a transparent material.

7. A non-contacting position detecting apparatus according to any preceding claim, wherein an end portion of said needle-like indicating means (300) has a roughened surface.

8. A non-contacting position detecting apparatus according to any preceding claim, wherein said needle-like indicating means (300) is installed within a region defined between the extension lines of the optic axis (L0) of laser light radiated from said light emitting portion (12) and the optic axis (L1) of laser light received by said light receiving portion (15) when the detection point and said laser unit (10) are in the predetermined positional relationship.

9. A non-contacting three-dimensional measuring instrument of any preceding claim, wherein said arm (6) is movable in the directions of axes of coordinates of a rectangular coordinate system, and wherein

- a main shaft (31) is provided on said arm (6) such that the direction of the center axis thereof is directed in the direction of one of the axes of coordinates;
- a first intermediate arm (30) is provided for pivotal motion on said main shaft (31); and
- a second intermediate arm (20) is provided for pivotal motion on said auxiliary shaft (33); and
- said laser unit (10) makes an angle of approximately 45 degrees with respect to said main shaft (31), and said auxiliary shaft (33).

10. A non-contacting three-dimensional measuring instrument according to claim 9, wherein said laser unit (10) is mounted on said second intermediate arm (20) such that a reference point at a predetermined distance in the laser light irradiation direction may be positioned at the crossing point between said main shaft (31) and said auxiliary shaft (33).

11. A non-contacting three-dimensional measuring instrument according to claim 9 or 10, wherein said laser unit (10) is constructed so as to irradiate laser light from a position other than a central portion thereof, and wherein said laser unit (10) can be mounted reversely with regard to its front and rear sides.

12. A non-contacting three-dimensional measuring instrument according to claim 9, 10 or 11, wherein said first, intermediate arm (30) includes a core member, made of an epoxy honeycomb (3035,3036), a pair of bearings (3032,3034) disposed at the opposite ends of said core member, and carbon fibers wound on the surfaces of said core member (3035,3036) and said bearings (3032,3034).

Patentansprüche

1. Berührungslose Positionserfassungsvorrichtung umfassend:

- eine Lasereinheit (10) mit einem lichtabgebenden Abschnitt (12) und einem lichtempfangenden Abschnitt (15) zum Ausstrahlen von Laserlicht auf einen Erfassungspunkt eines zu vermessenden Gegenstands und zum Empfangen von vom Erfassungspunkt reflektiertem Laserlicht um den Abstand zum Erfassungspunkt zu erfassen;

- einen zum Bewegen der Lasereinheit (10) in der Richtung wenigstens einer Achse eines rechtwinkligen Koordinatensystems geeigneten Arm (6); und

- ein Koordinatenpositioniermittel (1A) zum Er- fassen von Koordinaten des Arms (6), wobei Koordinaten des Erfassungspunktes gemäß der Koordinaten des Arms (6) erfasst werden, wenn die positionsmäßige Beziehung zwischen dem Erfassungspunkt und der Lasereinheit (10) eine vorbestimmte Beziehung er-
durch gekennzeichnet, daß die Lasereinheit (10) ein nadelartiges Anzeigemittel (300) umfasst, um den Kreuzungspunkt zwischen den Erstreckungslinien einer optischen Achse ($L_2$) von vom lichtabgebenden Abschnitt (12) ausgestrahltm Laserlicht und einer optischen Achse ($L_1$) von durch den lichtempfangenden Abschnitt (15) empfangenem Laserlicht anzuzeigen, wenn der Erfassungspunkt und die Lasereinheit (10) die vorbestimmte positionsmäßige Beziehung erreichen.

2. Berührungslose Positionserfassungsvorrichtung nach Anspruch 1, wobei das nadelartige Anzeigemittel (300) einfach entfernbar an der Lasereinheit (10) befestigt ist.

3. Berührungslose Positionserfassungsvorrichtung nach Anspruch 1 oder 2, wobei das nadelartige Anzeigemittel eine an der Lasereinheit (10) befestigte Grundplatte (303), einen ein Gewindeloch (301a) aufweisenden und mit einer vergleichsweise geringen Haltekraft an der Grundplatte (303) befestigten Halteabschnitt (30) und eine in das Gewindeloch (301a) des Halteabschnitts (301) geschraubte Nadel (302) umfaßt.

4. Berührungslose Positionserfassungsvorrichtung nach Anspruch 3, wobei die Grundplatte (303) und der Halteabschnitt (301) durch eine magnetische Kraft aneinander befestigt sind.

5. Berührungslose Positionserfassungsvorrichtung nach einem der vorhergehenden Ansprüche, wobei das nadelartige Anzeigemittel (300) darin eingebaut ist, daß Laserlicht auf einen Endabschnitt desselben gestrahlt werden kann.


7. Berührungslose Positionserfassungsvorrichtung nach einem der vorhergehenden Ansprüche, wobei ein Endabschnitt des nadelartigen Anzeigemittels (300) eine aufgerauhte Oberfläche aufweist.

8. Berührungslose Positionserfassungsvorrichtung nach einem der vorhergehenden Ansprüchen, wobei das nadelartige Anzeigemittel (300) einer Erstreckungslinie der optischen Achse ($L_2$) von vom lichtabgebenden Abschnitt (12) ausgestrahltm Laserlicht und einer optischen Achse ($L_1$) von durch den lichtempfangenden Abschnitt (15) empfangenem Laserlicht begrenzten Bereich angebracht ist, wenn sich der Erfassungspunkt und die Lasereinheit (10) in der vorbestimmten positionsmäßigen Beziehung befinden.

9. Berührungsloses dreidimensionales Meßgerät nach einem der vorhergehenden Ansprüchen, wobei der Arm (6) bewegbar in den Richtungen von Koor- dinatenachsen eines rechtwinkligen Koordinatensystems ist und wobei

- eine Hauptwelle (31) derart am Arm (6) vorge- sehen ist, daß die Richtung ihrer Mittelachse in die Richtung einer der Koordinatenachsen ge- richtet ist;

- ein erster Zwischenarm (30) zur Schwenkbewegung an der Hauptwelle (31) vorgesehen ist;

- eine Hilfswelle (33) derart am ersten Zwischen- arm (30) vorgesehen ist, daß sie einen Winkel von 45° bezüglich der Hauptwelle (31) bildet; und

- ein zweiter Zwischenarm (20) zur Schwenkbewegung an der Hilfswelle (33) vorgesehen ist und wobei ferner

- die Lasereinheit (10) am zweiten Zwischenarm (20) derart angebracht ist, daß die Richtung des von der Lasereinheit (10) ausgestrahlten Laserlichts einen Winkel von annähernd 45° bezüglich der Hilfswelle (33) bildet.

10. Berührungsloses dreidimensionales Meßgerät nach Anspruch 9, wobei die Lasereinheit (10) am zweiten Zwischenarm (20) derart angebracht ist, daß ein Bezugspunkt in einem vorbestimmten Abstand in der Laserlicht-Ausstrahlungsrichtung am Kreuzungspunkt zwischen der Hauptwelle (31) und der Hilfswelle (33) liegen kann.

11. Berührungsloses dreidimensionales Meßgerät nach Anspruch 9 oder 10, wobei die Lasereinheit (10) derart aufgebaut ist, daß Laserlicht von einer von einem Mittenabschnitt der Lasereinheit (10) abweichenden Position ausgestrahlt wird, und wobei die Lasereinheit (10) umgedreht bezüglich ihrer Vorder- und Rückseite angebracht werden kann.

12. Berührungsloses dreidimensionales Meßgerät nach Anspruch 9, 10 oder 11, wobei der erste Zwischenarm (30) ein aus einer Epoxy-Wabe (3035, 3036) hergestelltes Kernteil, ein an den entgegen- gesetzten Enden des Kernteils angeordnetes Paar von Lagern (3032, 3034) und auf die Oberflächen des Kernteils (3035, 3036) und der Lager (3032, 3034) gewickelte Kohlefasern umfaßt.
Reven
dications

1. Dispositif de détection de position de position sans contact comprenant :
   
   une unité laser (10) ayant une partie d'émission de lumière (12) et une partie de réception de lumière (15) irradiant une lumière laser sur un point de détection d'un objet de mesure et recevant une lumière laser réfléchie par le point de détection, afin de reconnaître la distance au point de détection ;
   
   un bras (6) pouvant déplacer ladite unité laser (10) dans la direction d'au moins un axe d'un système à coordonnées rectangulaires ;
   
   un moyen de détection de coordonnées (1A) détectant les coordonnées dudit bras (6), et dans lequel les coordonnées du point de détection sont reconnues d'après les coordonnées dudit bras (6) lorsque la relation de position entre le point de détection et ladite unité laser (10) atteint une relation prédéterminée ; caractérisé en ce que ladite unité laser (10) comprend un moyen d'indication (300) en forme d'aiguille, indiquant le point d'intersection entre des lignes d'extension d'un axe optique (L₀) d'une lumière laser rayonnant de ladite partie d'émission de lumière (12) et d'un axe optique (L₁) d'une lumière laser reçue par ladite partie de réception de lumière (15), lorsque le point de détection et ladite unité laser (10) atteignent la relation de position prédéterminée.

2. Dispositif de détection de position sans contact selon la revendication 1, dans lequel ledit moyen d'indication (300) en forme d'aiguille est facilement fixé de manière amovible à ladite unité laser (10).

3. Dispositif de détection de position sans contact selon la revendication 1 ou la revendication 2, dans lequel ledit moyen d'indication en forme d'aiguille comprend une plaque de base (303) fixée à ladite unité laser (10), une partie de support (30), ayant un trou taraudé (301a) et fixée à ladite plaque de base (303) à l'aide d'une force de maintien comparativement faible, et une aiguille (302) vissée dans ledit trou taraudé (301a) de ladite partie de support (301).

4. Dispositif de détection de position sans contact selon la revendication 3, dans lequel ladite plaque de base (303) et ladite partie de support (301) sont fixées entre elles par une force magnétique.

5. Dispositif de détection de position sans contact selon l'une quelconque des revendications précédentes, dans lequel ledit moyen d'indication (300) en forme d'aiguille est disposé de manière qu'une lumière laser puisse rayonner au niveau de sa partie d'extrémité.

6. Dispositif de détection de position sans contact selon l'une quelconque des revendications précédentes, dans lequel ledit moyen d'indication (300) en forme d'aiguille est conçu à partir d'un matériau transparent.

7. Dispositif de détection de position sans contact selon l'une quelconque des revendications précédentes, dans lequel une partie d'extrémité dudit moyen d'indication (300) en forme d'aiguille présente une surface rugueuse.

8. Dispositif de détection de position sans contact selon l'une quelconque des revendications précédentes, dans lequel ledit moyen d'indication (300) en forme d'aiguille est installé dans une zone formée entre les lignes d'extension de l'axe optique (L₀) d'une lumière laser rayonnant de ladite partie d'émission de lumière (12) et de l'axe optique (L₁) d'une lumière laser reçue par ladite partie de réception de lumière (15), lorsque le point de détection et ladite unité laser (10) se trouvent dans la relation de position prédéterminée.

9. Instrument de mesure en trois dimensions sans contact selon l'une quelconque des revendications précédentes, dans lequel ledit bras (6) est déplaçable dans les directions des axes de coordonnées d'un système de coordonnée rectangulaire, et dans lequel

   un arbre principal (31) est prévu sur ledit bras (6), de manière que la direction de son axe soit orientée dans la direction dans l'un des axes des coordonnées ;
   
   un premier bras intermédiaire (30) est destiné à effectuer un mouvement pivotant sur ledit arbre principal (31) ;
   
   un arbre auxiliaire (33) est prévu sur ledit premier bras intermédiaire (30), de manière à former un angle de 45° avec l'arbre principal (31) ;
   
   un deuxième bras intermédiaire (30) est destiné à effectuer un mouvement pivotant sur ledit arbre auxiliaire (33) ;
   
   ladite unité laser (10) étant montée sur ledit deuxième bras intermédiaire (20) de manière que la direction de la lumière laser rayonnant de ladite unité laser (10) forme un angle d'à peu près 45° avec l'arbre auxiliaire (33).

10. Instrument de mesure en trois dimensions sans contact selon la revendication 9, dans lequel ladite unité laser (10) est montée sur ledit deuxième bras intermédiaire (20) de manière qu'un point de réfé-
rence, se trouvant à une distance prédéterminée dans la direction de rayonnement de lumière laser, puisse être disposé au niveau du point d'intersection entre ledit arbre principal (31) et ledit arbre auxiliaire (33).

11. Instrument de mesure en trois dimensions sans contact selon la revendication 9 ou la revendication 10, dans lequel ladite unité laser (10) est conçue de manière à rayonner une lumière laser à partir d'une position autre que sa partie centrale, et dans lequel ladite unité laser (10) peut être montée de façon inverse par rapport à ses côtés avant et arrière.

12. Instrument de mesure en trois dimensions sans contact selon la revendication 9, 10 ou 11, dans lequel ledit premier bras intermédiaire (30) comprend un organe formant noyau, constitué d'une structure en nid d'abeilles en époxy (3035, 3036), d'un couple de paliers (3032, 3034) disposé aux extrémités opposées dudit organe formant noyau, et de fibres de carbone enroulées sur les surfaces dudit organe formant noyau (3035, 3036) et desdits paliers (3032, 3034).